TYPE II PROGRESS REPORT

Sept. 15,1972 - March 15, 1973

Utilizing ERTS-A Imagery for Tectonic Analysis Through Study of the Bighorn Mountains Region. MMC #256
ERTS Contract #NAS5-21852

Principal Investigator - Richard A. Hoppin UN 633

The investigation is proceding smoothly. 61 MSS scenes and 7 RBV scenes are on hand, most of which include all channels. Of these, 34 MSS scenes are being utilized for analysis. Only the south central portion of the Black Hills is not sufficiently cloud free to be workable.

The only problem encountered has been with completion of partial shipments. For example, on a data request sent October 30, 1972, of a total of 81 data products requested, 60 products were delivered but 21 were missing. None of the missing products has been received. We do not know whether certain frames are not of good quality or whether they just were not processed. It would be helpful if the reason for the lack of a particular frame could be specified. At this point we don't know whether to reorder the missing frames, or wait for them to be sent.

In our analysis of the various scenes, we begin with a study of the 70 mm transparencies using a Richards light table with a Bausch Lomb traveling binocular to view the scenes both singly and in stereo with sidelapping scenes. For overlays we have been using 9 x 9 negative prints made on our Omega enlarger. These, particularly MSS 7, provide the best definition for geologic structure analysis. Our photo service has made negatives from which we have made positive prints of quite good quality. The photo service has made two very fine positive enlargements of scene 1085-17294 (MSS bands 5 and 7) at a scale of 1:250,000; this makes possible direct comparison with our previously compiled structural syntheses on 1:250,000 topographic maps. Color enhancementof several scenes has been carried out on the I$^2$S Addcol viewer. Color infrared composites were photographed with tripod-mounted 35 mm cameras. Excellent 2 x 2 slides and color prints were obtained. In addition our photo service has tried out the diazo process; a 70 mm composite of scene 1085-17294 is exceptionally clear and provides an image of even better resolution and clarity than the Addcol.

The excellent U-2 photography taken in August has been annotated and plotted on the 1:250,000 maps. The 9 x 9 RC-10 aerochrome infrared transparencies are truly spectacular in the detail provided; currently this is being given much attention for both drainage and vegetational analysis.

As back up for the coming summer's field checking we have all the available 1:24,000 topographic maps and have on hand the conventional high altitude black and white photography for ground study chosen on the basis of the ERTS imagery study.

For both geomorphic and geologic analysis, MSS bands 5 and 7 provide the best images for study. What RBV imagery we do have, has not been nearly as useful as MSS imagery. We have assembled mosaics from 9 x 9 negative prints of bands 5 and 7. We are also going to assemble mosaics of positive prints of bands 5 and 7 obtained from GSFC.

The PI attended the ERTS-1 symposium of March 5-9, 1973. He presented a paper on Structural Interpretations Based on ERTS-1 Imagery, Bighorn Region, Wyoming-Montana. A copy of the abstract is enclosed along with a tectonic overlay of scene 1085-17294. The concentration of linears in the Bighorn uplift is striking. Folds in the Bighorn Basin are visible where not covered by Eocene and younger deposits. Without question the imagery provides an unparalled structural overview. Even though structures in the basin may be covered, extrapolation from the bordering structures revealed on the imagery would be warranted. In regions where far less is known of the geology than here, one might predict the subsurface occurrence of folds and lineaments and hence more confidently explore the covered areas for concealed oil structures and mineral deposits. The imagery allows one to more efficiently plan supporting lower altitude aircraft coverage, to select pertinent available photography and to plan ground field work and geochemical prospecting and geophysical surveys.

During the last 2 month period coinvestigator Richard G. Baker has begun his vegetation analysis.

The vegetation zonation of the Bighorn Mountains and surrounding area is generally similar to that of other Wyoming Ranges. The broad pattern consists of chenopod and sagebrush steppe in the Bighorn basin and short grass prairie in the Powder River basin; ponderosa pine and douglas fir at low elevations in the Bighorn Mountains, lodgepole pine at middle elevations; engelmann spruce and subalpine fir forests adjacent the upper treeline; and tundra or bare rock above treeline. The detailed pattern is a complex mosaic of overlapping vegetation types, whose distribution is probably controlled by slope direction, cold air drainage down valleys, moisture availability, and other local features. Spruce-fir forests, for example, often extend down valleys into the lodgepole or ponderosa-douglas fir types, probably because of moisture and cold air drainage.

Baker has been determining what separations can be made of these various types of vegetation from the ERTS MSS bands. Forest Service maps showing detailed distribution of dominant forest types have been obtained and are being colored for rapid analysis of the vegetation. These maps are being compared with color-additive images produced on the $I^2S$ Mini-Addcol viewer at the Iowa Geological Survey, and with images of MSS bands 5 and 7. Patterns on the ERTS imagery match those on the Forest Service maps quite well. The following separations summarize work to date:

1. In the Bighorn basin, sagebrush steppe, chenopod steppe, and cultivated areas seem to be distinct.

2. Lower treeline is, of course, very distinct - especially at coniferous forest boundaries.
3. Ponderosa pine and Douglas fir stands at low elevations may be distinct from other conifers, but more work is needed to be sure. They often occur in stands too small to recognize.
4. Lodgepole pine stands may be distinct from other conifers, but more work is needed to be sure. The area of lodgepole dominance appears to be subtly, but distinctly mappable.
5. Spruce-fir stands can be recognized where the stands themselves are large enough.
6. The upper treeline is usually very sharp and distinct.
7. Areas of rock are distinct from areas of tundra vegetation.
8. Among other vegetation types present, aspen, cottonwood, and willow have not been recognized. They occur in the area mapped by the Forest Service in stands too small to be clearly visible on the ERTS images. Aspen, especially, is abundant in other areas, and he expects to be able to map it.

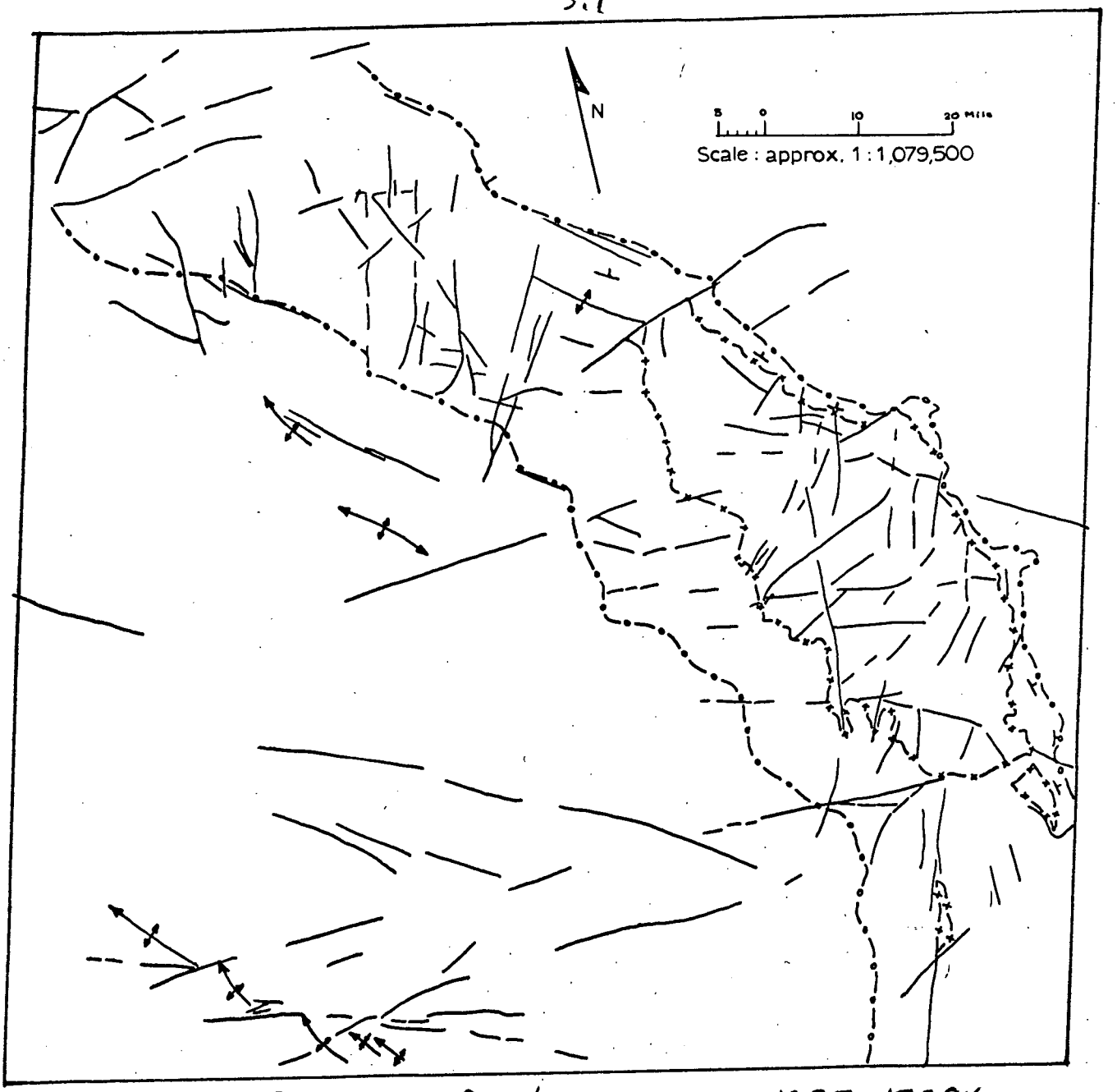
The balance of this spring and early summer will be spent completing our comparison of Forest Service maps and ERTS images. Baker will also look at U-2 photography. A preliminary map should be completed by mid-summer for field checking.

A request has been made to renew coverage during the late spring (April 15-June 15) in order to evaluate the seasonal effects particularly to differentiate non-conifer vegetation types and to help separate soil characteristics from vegetation.

One Data Request Form was sent on February 7, 1973. This was a request for positive prints to construct mosaics of bands 5 and 7. The "dodged" positives will also be compared with "regular" positives.

During the next period annotation of the remaining best images should be largely completed. If new spring imagery is received, this will be examined. Planning for the summer field checking is on schedule.

It might be noted that this project is involving students in several ways. Six graduate students will be using the imagery either to assist in their geologic field studies or to specifically examine areas of interest revealed by the imagery. In addition coinvestigator Drake has used the imagery as part of his classwork in his course in Advanced Geomorphology.




Linears and fold axes. Overlay on scene 1085-17294

—•—•—• Outline of Bighorn Uplift

—x—x—x Precambrian - Cambrian boundary

—— Linears

↕ Fold axes

Summary of significant results (1B)

Preliminary vegetation analysis has been undertaken on MSS scene 1085-17294, Oct. 16, 1973 in the Bighorn region. Forest Service maps showing detailed distribution of dominant forest types have been compared with MSS bands 5 and 7 positive transparencies, enlarged positive prints and color-additive images produced on an $I^2S$ Addcol viewer. Patterns on the ERTS imagery match those on the Forest Service maps quite well. Upper and lower conifer treelines are well marked. Separation of conifer types is possible for the larger stands, but more difficult in smaller stands or in mixed growth areas. Bare rock can be distinguished from tundra. Deciduous stands are not clearly marked on this fall imagery; late spring imagery needs to be examined.

Summary of significant results (3K)

A tectonic map overlay of MSS band 7 of the Bighorn region (1085-17294) reveals a strong concentration of linears in the uplift as compared to the basins. Folds in the Bighorn Basin are visible where not covered by post-Paleocene deposits. As folds are known in the subsurface under this cover, this suggests that extrapolation from the bordering areas would be warranted. In other words, in regions where far less is known of the geology than in this area, one might predict the subsurface occurrence of folds and lineaments on the basis of imagery analysis and more confidently explore covered areas for concealed oil structures and mineral deposits.

# STRUCTURAL INTERPRETATIONS BASED ON ERTS-1 IMAGERY, BIGHORN REGION, WYOMING-MONTANA

Richard A. Hoppin
Department of Geology
University of Iowa
Iowa City, Iowa 52242

Structural analysis in the region is being carried out on bands MSS 5 and 7 of scene 1085-17294. Geologic structure is primarily revealed in the topographic relief and drainage patterns. Topography is especially emphasized on positive transparencies of band 7 and stands out well both in mono-viewing, and in stereo-viewing of side-lapping scenes. Contrasts have been enhanced on enlarged negative prints at several different exposure times.

Topographic linears and drainage are particularly well developed in the Bighorn uplift. Strong linears follow known faults and shear zones in the Precambrian core. Several have not been previously mapped. The Tongue River lineament, long a source of controversy regarding its existence, stands out strongly. These features, however, either do not continue into the younger rocks of the flanks or do so in a much less marked manner than in the core. Their continuations into the basins are very problematical and possibilities of their extensions are manifest only in very subtle tone contrasts and straight drainage segments which will be field checked next summer. Prominent linear directions are E-W, NNE-SSW, NE-SW, and a less pronounced one NW-SE. It is tentatively concluded that these prominent linears represent very old features, only partially reactivated during the Cenozoic. Lack of delineation in the basins suggests that:

1). the thick cover has masked or absorbed the later movements,
2). the later movements have been mainly restricted to the present uplift and
3). the later displacements are predominantly dip-slip rather than strike slip.

Analysis of the imagery appears to support a mosaic pattern of blocks in the uplift, an hypothesis originally proposed on the basis of ground studies.

Vegetation contrasts are not too helpful in providing structural information. Conifer-bearing Cretaceous sandstones do outline a few hogbacks, particularly around the Black Hills and some of the larger sandstone-capped mesas in the basins. Within the Precambrian core of the Bighorns, portions of dikes greater than 150 feet wide are marked by vegetational contrasts from the surrounding gneisses.

An RBV scene of the same region (1013-17291) does not show as much detail as the MSS scene. An enlarged, enhanced negative print (band 2) nevertheless provides a view that still can be of use alone.

The ERTS imagery provides the basis on which targets for field checking and for supportive aircraft coverage can be efficiently chosen. Without this we would literally be feeling our way trying to verify the presence or absence of lineaments in the basins.